THE EQUATIONOR.

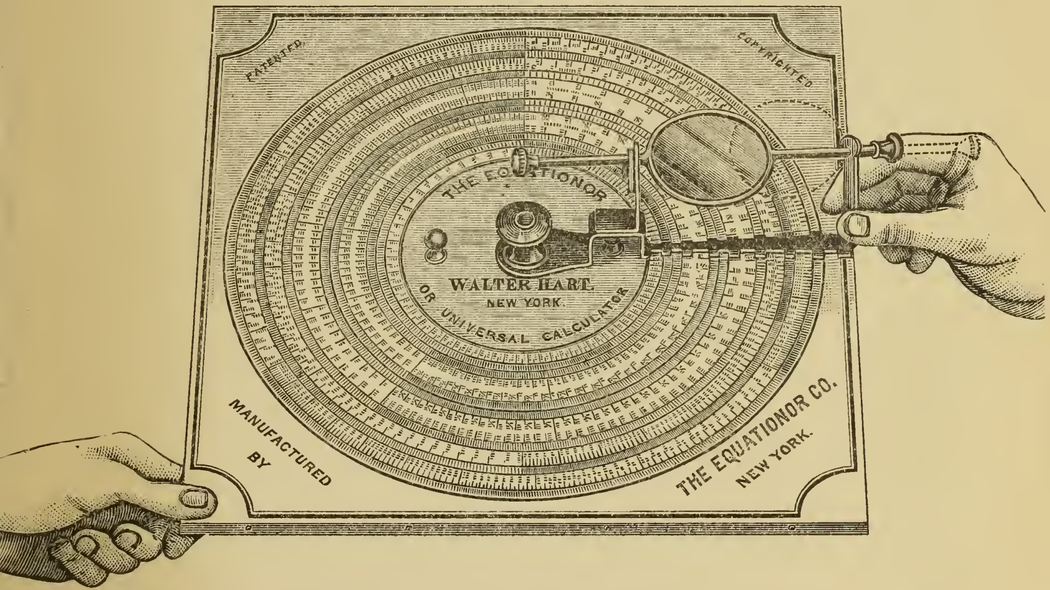
Arithmetic without Figuring.

BOOK OF INSTRUCTIONS

FOR THE

EQUATIONOR,

OR UNIVERSAL CALCULATOR.



This compact Instrument (8 inches square) gives rapid and correct solutions to simple and complex arithmetical problems, requiring (*only*) the application of those rules which are in daily use in commercial practice.

By WALTER HART.

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THE EQUATIONOR,

An Instrument for Easily and Rapidly Solving Arithmetical Questions.

PART FIRST.

THE EQUATIONOR is applicable to the needs of all classes, whether commercial, manufacturing, scientific, mechanical or otherwise. It has a usefulness for the merchant, the manufacturer, the contractor, the engineer, the machinist, the architect, the carpenter and builder, the banker and broker, and so on through all callings and many of the professions. It is a concentration of the arithmetic of daily demand ; it gives solution to questions ranging from multiplication or division by 2, to complex problems in involution and evolution. The province of this book is to show that with the "Equationor," and the application of that division of arithmetic called Proportion, or else that other division called Fractions, such far reaching results can be obtained. There is a trite saying, "Life is short,"—in other words, make it as long as you can, by effecting every labor in as short a time as you can ; to that end in regard to arithmetical labor the "Equationor" is brought to your notice, and its price made so moderate as to bring it within reach of the multitude.

The "Equationor" consists of a series of circular scales inscribed (in the same plane) on the faces of two metal plates, the inner and upper revolving on the outer and under. It belongs to that class of devices called slide rules, a device that would be in universal use were its valuable time-saving and exact qualities better known.

The scales of the Equationor are so marked, numbered and arranged, the one to the other, that arithmetical results are quickly produced. To effect such results or the solution of questions the inner set of scales called the Slide (white ground) has motion within the outer set of scales called the Rule (green ground). By this action the relative position of marks or numbers on either Slide or Rule can be changed in regard to the marks and numbers on the other. By bringing a mark or value that is on a scale of one part in line with a mark or value on a scale of the other part, problems are set and their solutions or answers effected. To effect solutions on the Equationor the operator needs but to use the rules governing Proportion or Ratio, or those governing Fractions, or both, as may best suit him. He is asked to carefully read the matter herein presented relating to Proportion and to Fractions, before concluding which he will operate through. Endeavor has been made to make both clear, but the field is so large that any information must, relatively to it, be limited.

In Proportion we are instructed that it is necessary to know three quantities, so as to find the fourth quantity, and that these quantities are respectively termed Antecedents (that which precedes or is the cause), or Consequents (that which follows or is the effect) and that the three known quantities consist of an Antecedent with its Consequent, and another Antecedent whose Consequent has to be found. This leads to the Rule, by which all problems, whether simple or complex, are solved by the "Equationor" when Proportion is used.

RULE.—Bring any Antecedent on the one scale in line with its Consequent on the other scale, when in line with any other Antecedent (on the same scale as the first Antecedent) will be found that other Antecedent's Consequent (on the same scale as the first Consequent. Bear in mind that Antecedents and Consequents are relative terms, for an Antecedent in one equation can be a Consequent in another Equation. Likewise for Consequents. For instance, if for 70 cents 50 apples can be procured, how many can be procured for $1.40? In this money is the Antecedents and apples the Consequents, but per contra, should the question be: if 50 apples bring 70 cents, how much will 100 apples bring? Then Apples would be Antecedents and money the Consequents. Correct procedure is to consider the two similar (in kind) quantities as Antecedents and the one different (in kind) quantity as a Consequent. In the first question the two were money, but in the other they were apples.

In setting the scales for the first mentioned equation, bring the mark or numbering, 70, on the one scale—say scale A—in line with 50 on the other scale—say scale A′—when in line with 140 on B find 100 on B′; but for the second equation, bring 50 on A in line with 70 on A′; when in line with 100 on B find 140 on B′. The foregoing problems, simple as they are, point to the reasoning required for solving the most complex in Direct Ratio. To solve problems in Inverse Ratio the same rule applies, provided an inverse scale is used; such a scale marked E, will be found on the Slide. On this scale find the first Antecedent, bring it in line with its Consequent, either on A or B, then look for the other (or second) Antecedent on E, when its Consequent will be found in line with it on A or B, as the case may be, or the Antecedents can be found on A or B and the Consequents on E as per 11th, 12th and 13th examples.

ILLUSTRATION.—A specific result is produced by the labor of 40 men in the space of 30 days; how many days will 60 men take? The Antecedents here are men, the Consequents days; therefore, in line with 40 on scale E bring 30 on Scale A, when in line with 60 on E find 20 on A. In regard to the terms Antecedent and Consequent, those quantities primarily used are to be considered as the first Antecedent and the first Consequent. Antecedents and Consequents that follow are for all practical purposes second Antecedents and second Consequents, for each in its place bears that relation to the first.

Fractions also offer quick method of setting problems and effecting solutions. A Fraction, as we know, consists of a numerator aud denominator, separated (generally) by a horizontal line, the factor or factors above the line being the numerator, and the factor or factors below the line being the denominator. Rules which govern the presentation of fractions in figured or written calculations also prevail here. In all problems in Fractions a quantity (the numerator) has to be divided by another quantity (the denominator), the quotient being the solution or answer.

Both numerator and denominator may each consist of but one factor, as $\frac{1}{2}$, or $\frac{7}{10}$, or $\frac{140}{16}$, or $\frac{13.57}{219.28}$, or $\frac{5\frac{1}{12}}{4\frac{3}{7}}$, or else one can consist of one factor while the other contains more than one, or both may contain more than one factor, in which case the separate factors of each must be intermultiplied, as $\frac{3\times4}{5}$, or $\frac{6}{7\times8}$, or $\frac{9\times10}{4\times12}$, or $\frac{18.3\times72.16}{43.12\times108}$

There are instances when factors consist of quantities to which others are to be added or else subtracted. These can be stated as they are, as $\frac{116-12\times48+42}{96+7\times85-33}$, or the additions and subtractions can be previously made, and the fraction stated in net form, as $\frac{104\times90}{100\times52}$.

Quantities of mixed nature can be arranged in the form of a Fraction and a quotient found to suit, as $\frac{10\text{ ft.}\times85\text{ ft.}\times2\text{ ft.}\times70.3\text{ per cent.}\times1728\text{ cu. in.}}{8\text{ in.}\times4\text{ in.}\times2\text{ in.}\times100\text{ per cent.}\times1\text{ cu. in.}}$

To effect solution of a problem set as a Fraction the following operations are required:

FIRST.—Find the first factor of the numerator on the rule (green).

SECOND.—Find the first factor of the denominator on the Slide (white).

THIRD.—Bring them in line with each other, which will be in line with the same edge of the runnner or guide, and lock the setting.

1st Memo. : All the other factors both of the denominator and of the numerator are to be sought for on the slide (white).

FOURTH.—Find the next numerator *by passing the guide over the instrument;* when found hold the guide firmly in place, unlock the previous setting, then the Slide is free to move.

FIFTH.—Find the next denominator factor, and *by rotating the Slide* bring it in line with the same edge of the guide that was used to find the numerator factor, then lock the setting.

2d Memo. : The fourth and fifth movements are alternated as often as there are respective numerator and denominator factors.

3d Memo. : If the Fraction should end in a numerator factor. the quotient or answer will be found on the Rule (green) in line with that factor.

4th Memo. : If the Fraction should end in a denominator factor, the quotient or answer will be found on the Rule (green) in line with 1 on the slide (white).

5th Memo. : The only quantities which are to be sought for on the Rule (green) are the first numerator and the quotient.

Whenever a problem is set as a Fraction each member of it should contain both a denominator and a numerator. Should either be wanting in the sum or problem its absence should be supplied by unity (1), as $\frac{8\times16\times32}{3}$ can be written $\frac{8\times16\times32}{1\times1\times3}$, or $\frac{8\times16\times32}{1\times3}$ or $\frac{8\times16\times32}{3\times1}$, while $\frac{3}{8\times16\times32}$ can be written as $\frac{1\times1\times3}{8\times16\times32}$, or $\frac{1\times3}{8\times16\times32}$, or $\frac{3\times1}{8\times16\times32}$

As the last or ultimate factor is not affected by unity, unity can therefore be omitted in that member.

As progress is made in understanding the instrument, the reason for the application of Proportion or of Fractions will become apparent. To point to it, operating the Equationor will teach that problems consisting of three *known* quantities and *one or more unknown* quantity or quantities should be solved by Proportion, while those consisting of four or more *known* quantities and but *one unknown* should be solved by Fractions.

The operator, as he becomes efficient, will perceive that Proportion is often presented in the form of a Fraction, for its working formula is $\frac{b\times c}{a}$; therefore (if preferred) all workings by the scales, A, A′, B, B′ and E can be effected by application of the rules governing Fractions.

CONSTRUCTION.

Having stated the principles and rules underlying the use of the Equationor, its construction will be more fully described. It consists of:

1st: An outer and under plate, called the Rule, on which are inscribed (on a green ground) scales lettered respectively A, B, C, D.

Memo. : The Rule rotates on a projection placed underneath.

2d: An inner and upper disk, called the Slide, on which are inscribed (on a white ground) scales lettered respectively A′, B′, E.

Memo. : The Slide rotates around a central threaded pin.

3rd : A Guide or Runner (which supports a reading glass) the edges of which are formed of projections.

Memo. : The Guide rotates around the central threaded pin, its edges radiate from the centre of the instrument and are in exact alignment with the markings of the scale.

4th. : A Nut that travels on the central threaded pin.

Memo. : The Nut locks the Rule and Slide together, or by reverse action unlocks them.

The Scales A, B, C, D, also A′, and B′, read in the same direction, but scale E reads in the opposite direction.

Values—that is the figures and markings on the scales—read as follows:

Those on scales A and A′ from 10 to 100, Those on scales B and B′ from 100 to 1,000, Those on scale C from 100 to 10,000, Those on scale D from 1,000 to 1,000,000,	} Direct working.
Those on scale E from 100 to 1,000.	Inverse working.

Scale A on the Rule and scale A′ on the Slide abut on one another, their junction is termed the working-circle; with practice an operator will find that all values—be they greater or less than those marked thereon—can be read from off them; this will be shown further on.

Scales A, A′, B, B′ and E are used in solving questions or equations in Proportion and in Fractions; that is, in setting and reading antecedents with their consequents, or denominators with their numerators. Scale C contains the squares while scale D contains the cubes of the numbers which are on scales A and B; the relation that the scales A and B bear to C and D are such that A and B contain the roots while C and D contain the powers of numbers.

As there is not sufficient space to print each value in full, the Roman numerals, C and M, are used in combination with the Arabic; thus 41 C is 4100, while 1 M is 1,000, and so on, C for hundreds, M for thousands.

To perform Involution it is necessary to bring an edge of the *guide* in line with the number or root on scale A or B, then, carrying the eye along that edge until it reaches scale C, read the square, or else to scale D to read the cube; in Evolution bring an edge of the guide in line with the number on D if the cube root is desired, or with the number on C if the square root is required, and in the same way read the root from off of either A or B as the case may be.

An understanding of how to read the markings and numberings on the scales comes next in order. Examination will show that the spaces between the divisions vary, in fact no two are precisely the same; in the nine divisions reading from 10 to 100, 10 to 20 is the longest, and each succeeding division—reading to the right—is shorter than its preceeding, 90 to 100 being the shortest; this relation exists not only as regards the principal divisions but also obtains with the sub-divisions. In the formation of a scale of this character, the length from its first mark to its last is primarily determined, then the nine principal division and their sub divisions are marked in. The principle involved in such markings allows of their being valued or numbered to read, either from 1 to 10, from 10 to 100, from 100 to 1,000, or in any multiple of 10; by the same law though a scale be valued or marked in any one of such numberings it can be mentally read in any other numbering of the multiple of 10 as exemplified by the following graphic presentations.

1 100 *sub-div.* 2 100 *s. d.* 3 100 4 50 5 50 6 50 7 50 8 50 9 50 10

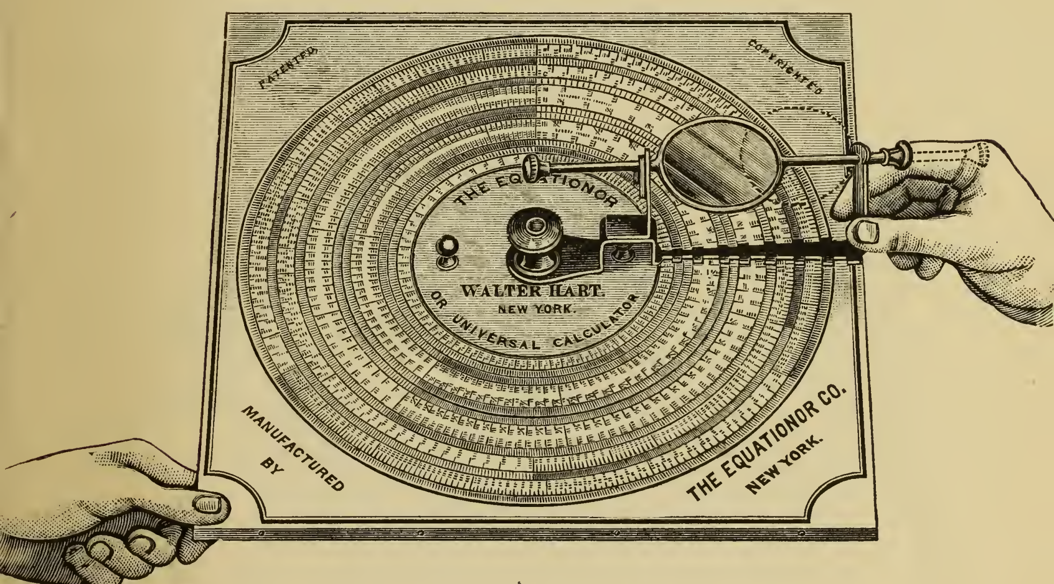
1	0 *on each line* 2	0 *o. e. l.* 3	0 *s. d.* 4	0 *s. d.* 5	0 *s. d.* 6	0 *s. d.* 7	0 *s.* 8	0 *s.* 9	0 *s.* 1	00
10	0 *in this* 20	0 *in t.* 30	0 *o. e.* 40	0 *o. e.* 50	0 60	0 70	0 *d.* 80	0 *d.* 90	0 *d.* 10	00
10	00 *space.* 20	00 *sp.* 30	00 *li.* 400	0 *li.* 500	0 600	0 700	0 800	0 900	0 10	000

With a knowledge of this property of the divisions, and with practice, it becomes as easy to read other values of the multiple of ten from off of any scale as it is to read the values marked thereon.

In the *Equationor* the nine principal divisions are subdivided as follows: there are 100 subdivisions between each of the three first and 50 subdivisions between each of the six others, each one of the 100 subdivisions between each of the first three principal divisions is to be read as a $\frac{1}{100}$ part of the value of such division, and each one of the 50 subdivisions between each of the other six principal divisions, is to be read as a $\frac{1}{50}$ or a $\frac{2}{100}$ part of the value of such division, in the instance of these latter marks or lines the eye can halve the space and so read to a $\frac{1}{100}$ part, with practice an operator can mentally divide the spaces between subdivisions so as to closely approximate to the $\frac{1}{100}$th part of the value of a principal division.

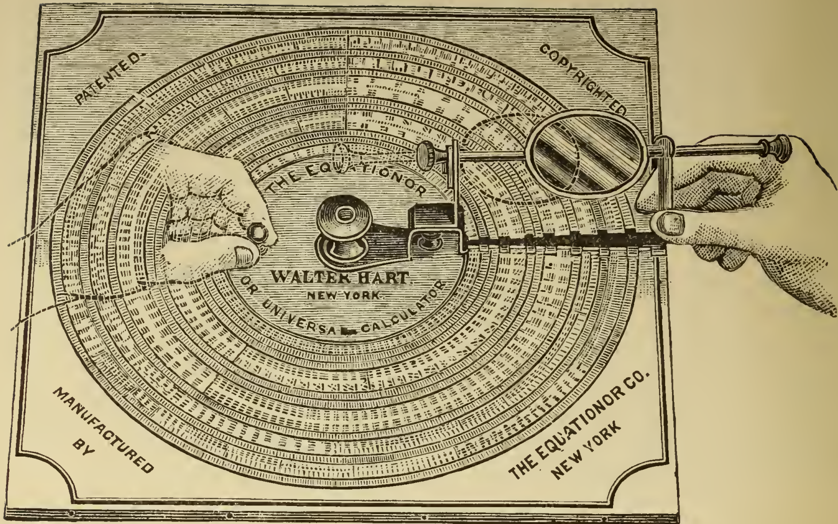
Accompanying cuts are to illustrate the method of operating the Equationor. Preferably the instrument should rest on a table, desk, or other firm support, but it can be operated held in the hand.

One hand rotates the Guide, while the other hand either rotates the Slide or tightens or loosens the Nut, or rotates the Rule, or shifts the Reading Glass as may be required by the necessities of the question or problem that is in process of solution.



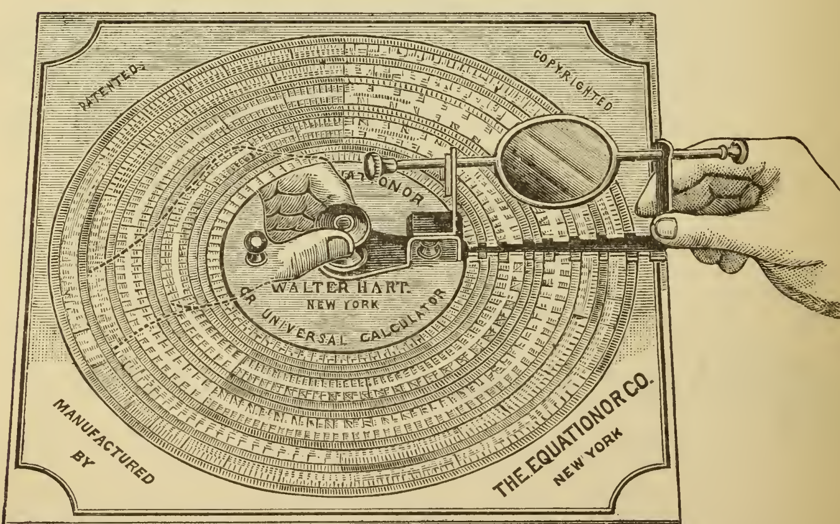
Cut No. 1.

When the instrument is so held it can be rotated as a whole or in combination with movement of the Guide or Runner. This position will generally be required at the beginning, when a quantity or value is to be found on the Rule. It is also the position by which proportionate and other values are found.



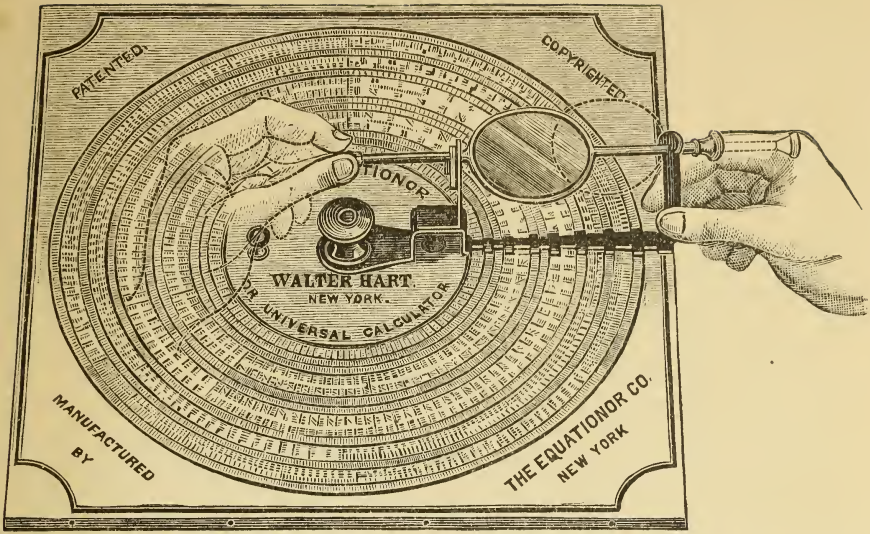
CUT No. 2.

In this position the one hand holds the Guide and Runner firmly in place, while the other hand rotates the Slide so as to bring a value thereon in line with the edge of the Guide, and per consequence in line with a specific value on the Rule.



CUT No. 3.

Shows the guide held firmly in place by the one hand, while the other either locks the Slide to the Rule or unlocks them by rotating the nut.



Cut No. 4.

Exemplifies how the Reading Glass is shifted so as to cover the field in use.

It will be noticed that the hand used in operating the Guide performs no other function. As both edges of the Guide and Runner radiate from the centre and are similarly recessed, the instrument can be operated by either a right-handed or a left-handed user.

THE EQUATIONOR.

PART SECOND.

Before applying this instrument to the solution of problems, the operator should learn as follows:

1st. How to handle the various moveable parts.

2d. How to read
3d. How to find
4th. How to combine } valuations on the Scales.

An operator should bear in mind:

FIRST.—The Rule governing Rule of Three, or Ratio or Proportion, which is: As any first quantity (termed first antecedent) is to a second quantity (termed first consequent) so is a third quantity (termed second antecedent) to a fourth quantity (termed second consequent) the first, second and third terms or quantities are known, the fourth term or quantity is unknown. This rule is expressed in symbols by the formulas $a : b :: c : x$, or $\frac{b \times c}{a} = x$ in which a, b, c represent the known quantities, while X represents the unknown quantity. Symbols are largely used in arithmetical formula, because they represent any quantity or value, while figures are limited to the quantity or value they express, as exemplified by the following equations, as 1 (a) is to 2 (b), so is 4 (c) to 8 (x) or as 3 (a) is to 9 (b), so is 12 (c) to 36 (x), other letters are also used for the known quantities, but x, y, z are generally used to express the unknown.

SECOND.—The rule governing the presentation of a fraction which is, the dividend written (generally) above a line underneath which the divisor is written as $\frac{a}{b} = x$ or $\frac{a \times b}{c \times d} = x$ or $\frac{a - b \times c + d}{e + f - g} = x$.

In Multiplication and in Division unity must be brought in line with the multiplier or with the divisor, in practice with the Equationor all such questions are solved by the formula $\frac{b \times c}{a}$

MULTIPLICATION.

1st Example: What will 16 yards cost at 6 cents per yard?

Argument: As 1 (a, the first antecedent) is to 6 (b, the first consequent), so is 16 (c, the second antecedent) to 96 (x, the second consequent).

Setting: Find 10 on scale A, bring in line with it 60 on scale A′ when in line with 16 on A find 96 on A′, the answer.

Reading: 10 on A as 1 yard, 60 on A′ as 6 cents, 16 on A as 16 yards, 96 on A′ as 96 cents.

GRAPHICAL SETTING:

A	10	16
A′	60	96

Otherwise:

A	a, 10	c, 16
A′	b, 60	x, 96

Remarks: As it would render a scale unwieldy to inscribe all values on it, the property that allows of increasing or decreasing the marked value in decimal ratio, has been made use of in this sum as it will be in general practice. In solving the foregoing example 10 on A was used as 1, and 60 on A′ as 6; for 10 is to 60 as 1 is to 6.

2d Example: What is the distance traversed in 52 hours, at a speed of 17½ miles per hour.

Argument: As 1 (*a*) is to 17½ (*b*), so is 52 (*c*) to its proportion (*x*).

Setting: Find 10 on A, in line with it bring 17.5 on A′, when in line with 52 on A find 910 on B′. the answer.

Reading: 10 on A as 1 hour, 17.5 on A′ as 17½ miles, 52 on A as 52 hours, 910 on B′ as 910 miles.

GRAPHICAL SETTING:

A	10	52
A′	17.5	
B′		910

Remarks: Scales A and B are continuations of one another; so also are scales A′ and B′, for where the one ends the other commences; this allows of increased or decreased readings—in decimal ratio—therefore while scale A′ is used for the first Consequent, scale B′ is used for the second Consequent.

3d Example: What will 102 bbls. of flour amount to at $11.40 per bbl.?

Argument: As 1 is to $11.40 so is 102 to its proportion.

Setting: In line with 10 on A bring 11.4 on A′. When in line with 102 on B find 116+ on B′, the answer.

1st Reading: 10 on A as 1 bbl., 11.4 on A′ as $11.40, 102 on B as 102 bbls., 116+ on B′ as 1160+

2d Reading: To produce more exact results in cases of + (plus) readings, divide the second Antecedent in two or more parts and add their results. In this example two parts are enough—one of 100 and one of 2; then in line with 100 on B find 114 on B′, to be read as $1140, and in line with 20 on A, to be read as 2, find 22.8 on A′, to be read as $22.80; adding $1140 and $22.80 makes a total of $1162.80.

GRAPHIC SETTING:

B° 100	* 102	
A* 10		° 20
A′* 11.4		° 22.8
B′ ° 114	* 116+	

* Values used in first reading.

° Values used in second reading.

Remarks: These examples should be sufficient to exemplify the action of the principle mentioned in the first part—that marked valuations can be increased or decreased in decimal ratio.

It is apparent that though lengthy explanations are needed to make clear the method of solving equations, when put in practice they require but a few seconds to effect results.

4th Example : Four lots of chairs have been sold, the separate lots containg 15, 25, 60, 110 chairs, a total of 210; the price per chair is 96 cents ; what does each lot amount to, and what is the total amount ?

Argument: As 1 is to 96 so is 15, 25, 60, 110 and 210 to their respective proportions.

Setting : In line with 10 on A bring 96 on A′ ; when in line with 15, 25, 60 on A find 14.4, 24, 57.6 on A′ ; and in line with 110, 210 on B, find 105+, 201+ on B′. As the two last Consequents are not exact, separate 110 into 100 and 10, when 100 on B will be in line with 96 on A′ ; and 10 on A in line with 960 on B′ ; separate 210 into 200 and 10, when 200 on B will be in line with 192 on B′ ; 10 on A in line with 96 on A′.

	B° 100	* 110		° 200	* 210		
GRAPHIC	A° * 10		* 15			* 25	* 60
SETTING :	A′ * 96		* 14.4			* 24	* 57.6
	B′ ° 960	* 105+		° 192	* 201+		

* First reading. ° Corrections of first reading.

Reading : 15, 25, 60 on A as 15, 25, 60 chairs, 14.4, 24, 57.6 on A′ as $14.40, $24. $57.60 ; 110, 210 on B as 110, 210 chairs; 960 on B′ and 96 on A′ as $9.60—and $96—together $105.60 ; 192 and 960 on B′ as $192 and $9.60, together $201.60.

Remarks : The product of the total quantity of chairs 210×96, $201.60, is sought for as a check on the total of the separate products.

DIVISION.

5th Example : $31 is to be divided among 25 persons ; what is the share of each ?

Argument : As 25 (a) is to 31 (b) so is 1 (c) to its proportion (x).

Setting : Bring 25 on A and 31 on A′ in line; when in line with 10 on A find 124 on B′, the answer.

	A	10	25
GRAPHIC SETTING :	A′		31
	B′	124	

Reading : 25 on A as 25 men ; 31 on A′ as $31 ; 10 on A as 1 man ; 124 on B′ as $1.24.

Remarks. This example, like those in multiplication, has the formula $a : b :: c : x$. Its Antecedents are persons and Consequents money.

6th Example : How many patterns of 16 yards each will 752 yards make ?

Argument : As 16 (a) is to 1 (b) so is 752 (c) to its proportion (x).

Setting : In line with 16 on A bring 10 on A′ ; when in line with 752 on B find 47 on A′, answer.

GRAPHIC SETTING :

B		752
A	16	
A′	10	47

Reading : 16 on A as 16 yards; 10 on A′ as 1 pattern ; 752 on B as 752 yards; 47 on A′ as 47 patterns.

MULTIPLICATION AND DIVISION.

There are frequent instances when a proportion or question contains many factors which are to be intermultiplied, one portion of them to be used as divisors of the other portion. In such instances the Equationor quickly effects a solution by the processes of multiplying and dividing alternately, operating under the following rule :

RULE. First write the problem in the form of a Fraction, the factors to be used in Division forming the denominator and the other factors forming the numerator, as $\left(\frac{a\times b\times c}{d\times e\times f}=x\right)$. Then using the Equationor, bring the first factor (a) of the numerator (on the Rule) in line with the first factor (b) of the denominator (on the Slide) and lock the scales; *after such setting all other factors, whether of the numerator or of the denominator, are to be looked for on the Slide, the same set of scales as the first denominator factor is on ;* having set and locked the scales, bring an edge of the guide in line with the second factor of the numerator (b), unlock the scales and bring the second factor of the denominator (e) in line with the edge of the runner, and so alternate as many times as there are numerator and denominator factors, when having set the last denominator factor and locked the scales, the answer will be found *on the Rule on the same set of scales as the first numerator factor is on ;* it will be in line with the last numerator or else with unity or 1 *on the slide or set of scales on which is the first denominator factor.*

7th Example : A freight car is 33 feet 10 inches long, 8 feet 1 inch wide, and 7 feet high, how many packages 6 inches high by 3⅝ inches square will it hold?

Argument : Reduce separately the factors of car measurement to inches, and apply them as numerators, and the factors of package measurement to inches and decimal parts ; apply them as denominators. This will present the example in the form of a fraction, reading as follows : $\frac{406''\times 97''\times 84''}{6''\times 3.625''\times 3.625''} = 41960.$

Operation : Set 406 (the first factor of the numerator) on B, in line with 6 (the first factor of the denominator) on A′; then lock the scales; move the guide to 97 (second factor of the numerator); on A′ unlock the scales and bring 3.625 (36.25) on A′ in line with edge of guide, then lock the scales ; move the guide to 84 (third factor of numerator) on A′, unlock the scales and bring 3.625 (third factor of denominator)—36.25—on A′ in line with edge of guide; then lock the scales ; move the guide to 1 (10) on A′, when in line with it on A will be found 41.96, to be read as 41,960, the answer.

Remarks : In such calculations it is not required to note the intermediate results, the final one only being required to be read. While the demonstration may seem extended, the solution of the foregoing problem was made in one minute.

This alternating property of the Equationor is very valuable, and those who will use it whenever possible will be amply rewarded for any time and effort spent in becoming efficient in its application, and it is only one of the many labor saving properties of the Equationor.

PROPORTION OR RATIO

Is either Direct or Inverse. It is Direct when both Antecedents and Consequents increase or decrease together ; it is Inverse when as the Antecedents increase the Consequents decrease, or vice-versa. In Direct Ratio the scales used are A, A′, B and B′. In Inverse Ratio the scales used are A, B and E, the latter being inversely marked in regard to the others; this feature of the Equationor is a great convenience, as it obviates reversal of the slide and gives coincident readings of reciprocals.

One of the many valuable properties of the Slide-Rule is, that the setting of a ratio includes all solutions in that proportion, be they few or many (while in figuring each requires a separate operation), this was shown in the 4th example.

The following examples are in illustration of the varying relation between Antecedents and Consequents.

Direct Ratio : When Consequents increase with Antecedents.

8th Example : If cloth is bought at the rate of 17 yards for $8.65, what will 855 yards amount to ?

Argument : As 17 is to 865 so is 855 to its proportion.

Setting : 17 on A in line with 865 on B′, when in line with 855 on B find 43.5 on A′.

GRAPHIC SETTING :

B		855
A	17	
A′		
B′	865	435

Reading : 17 on A as yards, 865 on B′ as $8.65, 855 on B as yards, 435 on B′ as $43.50, the answer.

Remark : Further on rules will be given to find the decimal point, so as to separate the integral from the decimal parts.

Direct Ratio : When Consequents decrease with Antecedents.

9th Example. If 565 gallons weigh 4270 lbs., what will 74 gallons weigh ?

Argument : As 565 are to 4270 so is 74 to its proportion.

Setting : 565 on B with 427 on B′, find 74 A with 559+B′, the answer.

GRAPHIC SETTING :

B	565	
A		74
A′		
B′	427	559+

Reading : 565 on B as gallons, 427 B′ as 4270 lbs., 74 on A as gallons, 559+ on B′ as 559+ lbs.

Direct Ratio : When one or more Consequents increase with Antecedents and one or more decrease with Antecedents.

10th Example : If 16 men can carry a beam weighing 1250 lbs., what respective weight of beam can be carried by 22 men and by 12 men.

Argument : As 16 is to 1250 so is 12 to its proportion ; 22 to its proportion.
Setting : 16 A with 125 B′ find 22 A with 172—B′, 12 A 937+B′, the answer.

GRAPHIC SETTING

A	12	16	22
A′			
B′	937+	125	172—

Reading : 16 A as men, 125 B′ as 1250 lbs ; 12 and 22 A as men ; 937+ and 172— B′ as 937 lbs. and 1720 lbs.

Remarks : Whenever the same setting calls for increased and decreased quantities, the larger will be found on the one side and the lesser on the other side of the setting.

Inverse Ratio : When Consequents increase as Antecedents decrease.

11th Example : If 65 men build a wall in 100 days, how many men will be required to build it in 50 days ?

Argument : As 100 is to 65, so is *inversely* 50 to its proportion.

Setting : 100 A with 650 E ; find 50 A with 130 E, the answer.

GRAPHIC SETTING :

A 50	100
E 130	650

Reading : 100 A as days ; 650 E as 65 men ; 50 A as days ; 130 E as 130 men.

Inverse Ratio : When Consequents decrease as Antecedents increase.

12th Example : If a wheel 1 and $\frac{6}{10}$ feet in diameter makes 1160 revolutions per minute, how many revolutions per minute must a wheel of 8 feet diameter make to travel the same peripheral distance ?

Argument : As 1.6 is to 1160, so is *inversely* 8 to its proportion.

Setting : 16 A with 116 E ; find 80 A with 232 E, the answer.

GRAPHIC SETTING:

80	A	16
232	E	116

Reading : 16 A as 1.6 feet, 116 E as 1160 rev.; 80 A as 8 feet, 232 E as 232 rev.

Inverse Ratio : When Consequents decrease as Antecedents increase, and Consequents increase as Antecedents decrease.

13th Example : A volume of gas enclosed in 4 cubic feet gives a pressure of 10 pounds. What will its pressure be if expanded to 8 cubic feet or contracted to 2 cubic feet ?

Argument : As 4 is to 10 so is *inversely* 8 and 2 to their respective proportions.

Setting : 40 A with 100 E ; find 80 A with 500 E ; 20 A with 200 E.

GRAPHIC SETTING :

80	A	20	40
500	E	200	100

Reading : 40 A as 4 c. f., 100 E as 10 lbs., 80 A as 8 c. f., 500 E as 5 lb., 20 A as 2 c. f., 200 E as 20 lbs.

General Remarks: The foregoing examples illustrate the varied applications of the principle involved in Proportion, and instruct the operator how to apply them either singly or in combination, according to the question they occur in.

Direct Proportion—When Consequents increase with Antecedents.
When Consequents decrease with Antecedents.
When Consequents both increase and decrease with Antecedents.

Inverse Proportion--When Consequents increase as Antecedents decrease.
When Consequents decrease as Antecedents increase.
When Consequents increase and decrease as Antecedents decrease and increase.

INTEGERS AND DECIMALS.

How to locate the Decimal point in Equationor practice. Slide Rule arithmetic, unlike figured arithmetic, does not present graphically the position of the decimal point; however, an operator will, with but little practice, intuitively place it.

On the Slide rule a single figure may be an integer or a decimal, two figures may be both integers, or one an integer and one a decimal, or both decimals; any number of figures may be all integers, part integer and part decimal, or all decimal. With the Equationor, placing the decimal point is governed by finding the integer and not the decimal, as in figuring.

When the solution, or answer, to an equation or problem consists of integers and decimals, or else of decimals only, the position the decimal point occupies in respect to the first figure of the decimal, also how many figures are in the integer (if any) are pointed out by the characteristic with its index which can be either minus (—) or plus (+), as illustrated by the following tabulation:

The integer may contain,			The decimal may contain,					Characteristic
No figure, or 0.			.0008,	or 3 ciphers to left of figure,				is —3
" "			.005,	or 2	"	"	"	is —2
" "			.03,	or 1	"	"	"	is —1
" "			.9,	or no	"	"	"	is ∓0
One place of figures	1 to	9	One or more figures,					is +1
Two " "	10 to	99	"	"	"			is +2
Three " "	100 to	999	"	"	"			is +3

The index of a minus (—) characteristic shows the number of ciphers that are placed to the left of the first figure in the decimal, there being no integers. The index of a plus (+) characteristic shows the number of figures in the integer. The index of a plus-minus (∓) characteristic is a cipher (0).

MULTIPLICATION.

The products are pointed off by the following rules:

1st Rule. When a product contains an integral part (+ characteristic) the index of the characteristic—a figure—is the sum of the indices of both factors.

2d Rule. When the product does not contain an integral part (∓ or — characteristic). In the instance of plus-minus (∓) the index—a cipher—shows that the decimal part commences with a figure. In the instance of minus (—) characteristic, the index—a figure—shows the number of ciphers to the left of the first figure in the decimal, which is equal to the difference between the number of places in the product and the number of places in the factors.

These rules are illustrated by the following tabulation, which on the Equationor would be $82 \times 37 = 3034$ for all the variations.

Multiply.	Product should contain.	Characteristic.	Reading.	
82 by 3.7	3 integers	+ 3.	303.4	1st Rule.
82 by .37	2 integers	+ 2.	30.34	1st Rule.
8.2 by .37	1 integer	+ 1.	3.034	1st Rule.
.82 by .37	no integer	∓ 0.	.3034	2d Rule, 1st part.
.82 by .037	no integer	— 1.	.03034	2d Rule. 2d part.
.082 by .037	no integer	— 2.	.003034	2d Rule. 2d part.

DIVISION.

The Quotient is pointed off by the following rules:

If the Dividend and Divisor both contain integral parts, or if the Dividend only contains an integral part.

1st Rule: When the Dividend has more figures in its integral part than there are figures in the integral part of the Divisor, then the difference—in number of figures—is the index of the + (plus) characteristic in the Quotient.

If neither Dividend nor Divisor contain integral parts.

2d Rule: When the first place in the Dividend is a figure and the first place or places in the Divisor is a cipher or ciphers, then the characteristic in the Quotient is + (plus), and its index is equal to the number of ciphers in the divisor.

3d Rule. When the first places in both Dividend and Divisor are figures, then the characteristic in the Quotient is ∓ (plus-minus), and its index a cipher.

4th Rule. When the same number of first places in both Dividend and Divisor contain ciphers, then the characteristic in the Quotient is ∓ (plus-minus), and its index a cipher.

5th Rule. When there are more first-place ciphers in the Dividend than there are first-place ciphers in the Divisor, then the characteristic in the Quotient is — (minus), and its index the difference between the ciphers.

These Rules are illustrated in the following tabulation by reversion of the multiplication tabulation. On the Equationor the Quotient of 3034 divided by 37 would be 82 for all the variations.

Divide	Quotients would contain:	Characteristic:	Reading:	Rule:
303.4 by 3.7	2 integers	+ 2	82.	1st
30.34 by .37	2 "	+ 2	82.	1st
3.034 by .37	1 "	+ 1	8.2	1st
.3034 by .037	1 "	+ 1	8.2	2d.
.3034 by .37	No "	∓ 0	.82	3d.
.03034 by .037	" "	∓ 0	.82	4th.
.003034 by .037	" "	— 1	.082	5th.

PROPORTION.

As this is the combination of multiplication and division the same rules apply, but familiarity with the principle that governs the characteristic will allow an operator to set his own rules.

FRACTIONS.

All answers on the Equationor (or any Slide Rule) are given in integers and decimals, or in decimals only; where it is requisite that other forms of fractions should be found, the change is effected by application of the formula $a : b :: c : x$. which will change fractions of any kind into fractions of another kind.

14th Example: How many 16ths are there in $\frac{25}{100}$ths?
Argument: As 100 is to 16 so is 25 to its proportion.
Setting: 100 on B with 16 on A′; find 25 on A with 40 on A′; answer.

GRAPHIC SETTING:

B	100	
A		25
A′	16	40

Reading: 100 B as unity (or the whole) divided into 100 parts
16 A′ as unity (or the whole) divided into 16 parts
25 A as 25 of the 100 parts
40 A′ as 4 of the 16 parts
The 2d anteced't being less than the 1st, th' 2d conseq't must be less than the 1st.
Decimal fractions changed to vulgar fractions or vice-versa.

15th Example: How many 27ths are there in $\frac{82}{560}$ths?
Argument: As 560 is to 27, so is 82 to its proportion.
Setting: 560 B with 27 A′; find 82 A with 395+B′.

GRAPHIC SETTING:

B	560	
A		82
A′	27	
B′		395+

Reading: 560 B, unity divided into as many parts.
27 A′, unity divided into as many parts.
82 A 82 of the 560 parts.
395+B 3.95+of the 27 parts.
Vulgar fractions changed from one kind to another.

An understanding of the processes relating to Multiplication, Division, Proportion, Decimal point and Fractions will qualify the operator to readily apply the scales A, A′, B, B′, and E to all problems soluble by the formula $a : b :: c : x$ whether in Direct or Inverse Ratio.

INVOLUTION AND EVOLUTION.

These are effected on the Equationor—with slight exception, which will be pointed out—by inspection only, for the scales C and D are so marked in respect to scales A and B, that values on A and B are the roots of values on C and D; being the square roots of values on C and the cube roots of values on D; therefore the values on C are the squares, and the values on D the cubes of values on A and B. Other powers are to be found by a method described further on.

16th Example: What are the squares and cubes of 5, 7, 9 and 12?

Argument: These powers are found by inspection.

Setting: Bring an edge of the guide in line with the root, when the square and cube will be in line with that edge.

Inspection shows :

GRAPHIC PRESENTATION :

D	125000	343000	729000	1728
C	2500	4900	8100	144
A	50	70	90	12

Reading: 50 on A as 5, 2500 on C as 25, 125000 on D as 125
70 " " 7, 4900 " " 49, 343000 " " 343
90 " " 9, 8100 " " 81, 729000 " " 729
12 " "12, 144 " "144, 1728 " "1728

One fig. (the right hand) being cancl'd in the root, two figs. must be cancl'd in the square and three figures in the cube.

Remarks : When a root consists of both integers and decimals, there are two decimals in the square and three decimals in the cube for each decimal there is in the root. Also relatively for higher powers.

17th Example : What are the square roots of 484, 961 and 2116. Also the cube roots of 1331, 9261, 50653 and 132657.

Inspection shows :

GRAPHIC PRESENTATION :

D	1331	9261			50653		132657
C			484	961		2116	
A	11	21	22	31	37	46	51+

Remarks : When a power contains both integers and decimals, there will be one decimal in the root for two decimals in the square or for three decimals in the cube, also relatively for higher powers. When a power higher than the square or the cube is desired, the method of its finding is pointed out by the following tabulation :

A number, is the root of its square and of its cube, &c. . or $a = \sqrt{a^2}\ \sqrt[3]{a^3}$

The square of a number is the { square root of the fourth power, or $a^2 = \sqrt{a^4}$
{ cube " " sixth " or $a^2 = \sqrt[3]{a^6}$

The cube of a number is the { square " " " " or $a^3 = \sqrt{a^6}$
{ cube " " ninth " or $a^3 = \sqrt[3]{a^9}$

4th power of a number is the { square " " eighth " or $a^4 = \sqrt{a^8}$
{ cube " " twelfth " or $a^4 = \sqrt[3]{a^{12}}$

This shows that by using the squares and cubes on C and D as roots on A and B, certain higher powers can be read by inspection. The above tabulation will find the 4th, 6th, 8th, 9th and 12th powers, omitting the 5th, 7th, 10th and 11th, which are to be found by multiplication. It is possible to combine the two operations, for instance : the 5th power is to be found by multiplying the 4th power by the root, or 1st power ($a^4 \times a = a^5$), (or $a^3 \times a^2 = a^5$). Then using the 5th power as a root, its square is the 10th power and its cube the 15th power. Such high powers are not needed in general practice, but the illustration is given to show that but one multiplication is required between the 1st and the 6th powers.

CONSTANTS.

A Constant is a factor created by the interaction of two or more factors; it replaces them, and by its use materially shortens arithmetical operations. It is generally used as a multiplier. Constants have been calculated in great variety, and tables of them are to be found in the majority of books containing mechanical and engineering formula; they should be used in Slide Rule practice to the fullest possible extent.

Great as their variety is, at times the particular one wanted—may have to be created. To effect this, the process is to take such of the factors of a formula as do not change their arithmetical value, and reduce them to one factor; this will be exemplified as follows:

What is the Constant for the weight of an inch in length of round iron of varying diameters, the weight per cubic foot being 487 lbs.

The factors in this problem are D^2 the square of the diameter, .7854 the Constant for the area of a circle inscribed in a square whose side is 1; 487 the lbs. in one cubic foot, 1728 the number of cubic inches in a cubic foot, the formula for all of which is $\frac{D^2 \times .7854 \times 487.}{1728}$ D^2 is a variable factor, while $\frac{.7854 \times 487}{1728}$ are invariable factors, and enter into each solution, therefore using them as a separate problem its quotient is .22135, which will give sufficiently close results if used as .221, applied as a multiplier to the squares of the seperate diameters, the formula for which is $D^2 \times .221$, the product being the weight of an inch of length of the round iron. By using the scales A, C and B′, but one setting is required to read the weight of one inch of any diameter.

18th Example. What is the weight per inch for 2″, 3″, 4″ and 5″ diameter, wrought iron?

Setting. 10 on A with 221 on B′.

Inspection shows:

C			400		900	1600	2500	
A	10	16	20	25	30	40	50	90
B′	221	354		553		884		199

Reading: 10 on A as 1 inch, 221 on B′, as .221, the Constant.
20, 30, 40, 50 on A, as 2″, 3″, 4″, 5″, the diameters.
400, 900, 1600, 2500 on C, as 4, 9, 16, 25, the squares.
16, 25, 40, 90 on A, as 4, 9, 16, 25, the squares.
354, 553, 884, 199 on B′, as .884, 1.99, 3.54, 5.53, pounds per inch of length.

Constants are not alone applicable in mechanical arithmetic, but are equally so in commercial and general arithmetic; with the Equationor they can be readily found and applied.

EQUIVALENTS.

Equivalents are another form of Constants. They can be found by calculation or by inspection. An Equivalent is a proportional quantity, replacing by an Antecedent and its Consequent other Antecedent or Antecedents, with respective Consequent or Consequents.

The Slide Rule, by inspection, offers the quickest way for finding Equivalents. A first Antecedent or a first Consequent or both may each consist of many figures; they

can be replaced by an Equivalent with fewer figures, allowing of more exact setting and reading.

19th Example. The area of a circle inscribed in a square whose side is 1 is equal to .7854 ; to find the area of a circle, the diameter being used as a factor, the setting would be 10 (representing 10.000) on A in line with 78.54 (representing .7854) on A′; inspection will show 14 on A in line with 11 on A′, also 20.5 on A in line with 16.1 on A′, either of which can be used as a setting in place of .7854 and 10 000.

GRAPHIC SETTING:

A	10	14	20.5
A′	78.5	11	16.1

205 with 161 is a more exact Equivalent than 14 with 11.

Slide Rule settings can all be read as Fractions, which allows of quick comparison. The foregoing settings can be read as $\frac{7854}{10000}$, or $\frac{11}{14}$ or $\frac{161}{205}$ of 1.

20th Example: What would be the cost per pound in dollars and cents for goods bought at 15 francs the kilogramme, exchange being $3.90 for 20 francs?

This problem requires two equations; the first is: as 20 francs is to $3.90 so is 15 francs to $2.925; this gives the cost per kilogramme, exchange included; a kilogramme is equal to 2.2+ pounds; therefore, the second equation is: as 2.2+ pounds is to $2.925 so is 1 pound to $1.33, the answer. Applying 15 (francs) as a first Antecedent, and 133 ($1.33) as its Consequent, the ratio can be used as an Equivalent for all costs per kilogramme, exchange being $3.90 for 20 francs.

21st Example: Under the foregoing rate of exchange what is the pound cost, the price per kilogramme being: 9f., 12f., 23f., 32 f.?

GRAPHIC SETTING:

A 12	15	23	32	90
A′ 10.65	13.3	20.4	28.4	80

Reading: 12, 15, 23, 32, 90 on A as 12f., 15f., 23f., 32f., 9 f.
10.65, 13.3, 20.4, 28.4, 80 on A′, as $1.06½, $1.33, $2.04, $2.48, 80f.

A table of very useful equivalents, by Wm. Cox, C, E., appeared January 3d, 1891, in *Engineeriag News*. By permission of that paper I herewith append them :

Quantities.	Equivalents.	Exact Ratio.	Error per cent.
Geometrical:			
Diameters of circles and circumference circles.	226=710	1= 3.14159	.00001+
Diameters of circles and side equal square......	79=70	1= .8862	.017 —
Diameters of circles and side inscribed square.	99=70	1= .7071	.004 —
Circumference circles and side equal square....	39=11	1= .282	.014 —
Circumference circles and side inscribed square.	40=9	1= .225	.036 —
Side of square and diagonal of square............	70=99	1= 1.4142	.005 +
Area square side = 1, and area circle, diameter = 1..	205=161	1= .7854	.0001 —
Area of circle and area inscribed square.........	11=7	1= .6366	.04 —
Arithmetical:			
Links and feet..	100=66	1= .66	None.
Links and inches..	12=95	1= 7.92	.05 —
Square links and square feet.......	101=44	1= .4356	None.
U. S. gallons and imp. gallons......................	6=5	1= .83312	.025 +
U. S. gallons and cubic inches............	1=231	1= 231.	None.
U. S. gallons and cubic feet......	800=107	1= .13368	.005 +
Imp. gallons and cubic inches......................	22=6100	1= 277.27	None.
Imp. gallons and cubic feet.....	430=69	1= .16046	None.
Metric System:			
Inches and centimeters..................................	26=66	1= 2.5399	.06 —
Feet and meters.....	82=25	1= .30479	.028 +
Yards and meters..	82=75	1= .91438	.028 +
Miles and kilometers......	31=50	1= 1.6093	.22 +
Links and meters..	4300=685	1= .20116	None.
Chains and meters................................	43=865	1= 20.116	None.
Square inches and square centimeters	31=200	1= 6.4513	.004 +
Square feet and square meters......................	140=13	1= .0929	.005 —
Square yards and square meters.....................	6=5	1= .83609	.3 —
Acres and hectares...	42=17	1= .40467	.022 +
Square miles and square kilometers...............	22=57	1= 2.5899	.17 +
Cubic inches and cubic centimeters...............	5=82	1= 16.386	.08 +
Cubic feet and cubic meters.........................	600=17	1= .02831	.015 —
Cubic yards and cubic meters	85=65	1= .76451	.025 +
Cubic feet and liters............	6=170	1= 28.315	.015 —
U. S. gallons and liters	14=53	1= 3.7855	.005 +
Imp. gallons and liters..................................	46=209	1= 4.5435	.0002 —
Grains and grammes......................................	108=7	1= .0648	.0023 +
Ounces and grammes..................................	6=170	1= 28.349	.015 —
Pounds and kilogrammes.......	75=34	1= .45359	.065 —
Hundredweights and kilogrammes..................	63=3200	1= 50.802	.018 —
British tons and metric tonnes.......	63=64	1= 1.016	.017 —
Pressures:			
Pounds per square inch and kilogrammes per square meter.................	640=45	1= .07031	.0004 +
Pounds per square foot and kilogrammes per square meter..	51=249	1= 4.8826	.006 —
Pounds per square yard and kilogrammes per square meter..	59=32	1= .54251	.027 —
Inches mercury and pounds per square inch....	57=28	1= .49116	.012 +
Inches mercury and pounds per square foot....	82=5800	1= 70.727	.006 +
Inches water and pounds per square inch.......	720=26	1= .03612	.004 —

Quantities.	Equivalents.	Exact Ratio.	Error per cent.
Pressures:—Continued.			
Inches water and pounds per square foot........	74=385	1= 5.2021	.01 +
Feet water and pounds per square inch..........	60=26	1= .4335	.04 —
Feet water and pounds per square foot..........	5=312	1= 62.425	.04 —
Inches mercury and feet water......................	15=17	1= 1.1334	.009 —
Atmospheres and inches mercury	97=2900	1= 29.922	.1 —
Atmospheres and pounds per square inch.......	34=500	1= 14.706	.007 —
Atmospheres and pounds per square foot........	34=7200	1=2116.8	.04 +
Atmospheres and kilogrammes per centimeter.	30=31	1= 1.033	None.
Atmospheres and feet of water......................	23=780	1= 33.9	None.
Atmospheres and meters of water..................	3=31	1= 10.33	None.
Pounds per square inch and feet of water.......	29=67	1= 2.311	.03 —
Kilogrammes per square centimeter and meters of water..	1=10	1= 10	None.
Combinations:			
Pounds per foot and kilogrammes per meter...	43=64	1= 1.4882	.007 +
Pounds per yard and kilogrammes per meter...	127=63	1= .49606	.0002 —
Pounds per cubic foot and kilogrammes per cubic meter..	49=785	1= 16.019	.006 +
Cubic feet per minute and liters per second....	89=42	1= .47192	.002 —
Imp. gallons per minute and liters per second.	700=53	1= .07572	.0013 —
U. S. gallons per minute and liters per second.	840=53	1= .06309	.0004 +
Weight fresh water and weight sea water........	38=39	1= 1.026	.006 +
Cubic feet water and weight in pounds..........	5=312	1= 62.425	.04 —
Imp. gallons water and weight in pounds.......	1=10	1= 10	None.
U. S. gallons water and weight in pounds.......	3=25		
Pounds per U. S. gallon and kilogrammes per		1= 8.333	None.
liter	50=6		
Pounds per imp. gallons and kilogrammes per		1= .11982	.015 —
liter	10=1		
Pounds per U. S. Gallon and pounds per imp.		1= .09983	.017 —
gallon..	30=25	1= .8333	None.
Cubic feet water and weight in kilogrammes....	3=85	1= 28.315	.015 —
Imp. gallons water and weight in kilogrammes.	46=209	1= 4.5435	.0002 —
U. S. gallons water and weight in kilogrammes.	14=53	1= 3.78551	.005 +
Feet per second and miles per hour	44=30	1= .6818	None.
Yards per minute and miles per hour.............	88=3	1= .03409	None.
Feet per second and meters per minute..........	41=750	1= 18.287	.027+
Feet per minute and meters per minute..	82=25	1= .3048	.025+
Foot pounds and kilogrammeters..................	340=47	1= .13825	.013 —
British horse power and French horse power...	72=73	1= 1.0138	.003 +
One cubic foot water per minute under feet of head and horse power (British)..................	3700=7	1= .00189	.0003 +
One liter water per second under meters of head and horse power (French)..................	75=1	1= .0133	None.

[We think we can guarantee the accuracy of the above ratios, and also that it is the most complete and useful table of the kind in print—in English at least.—Ed. Eng. News.]

SYMBOLS OR SIGNS.

It is to be accepted that the majority of Equationor operators will have knowledge and make application of the various symbols and signs that are used to abbreviate arithmetical workings, but in assistance of the minority those symbols or signs which are most frequently used are herewith given:

Operation:	Sign:	Formula:	
Multiplication,	$\times$	$a\times b$ or ab,	Operations which are performed by the Equationor.
Division,	$\div$	$a\div b$ or $\frac{a}{b}$	
Proportion,	:, : :, :	$a : b : : c : x$	
Involution or Powers,	2 or $\frac{1}{2}$, 3or $\frac{1}{3}$, &c.,	a, a^2, a^3, a^4. &c.	
Evolution or Roots,	$\sqrt{a}$, $\sqrt{a}$, $\sqrt{a}$,	$\sqrt{a}$, $\sqrt[3]{a}$, $\sqrt[4]{a}$.	

There are other signs that state the relation one quantity bears to another.

Relation:	Sign:	Formula:
To be added,	$+$, plus.	$a+b = c$.
To be subtracted,	$-$, minus.	$c-d = e$.
Neither added nor subtracted,	$\mp$, plus-minus	$e\mp f = g$.
Equal to,	$=$	$g=h=i$.
Greater than,	$>$	$i>k$.
Less than,	$<$	$k<l$.
The difference between,	$\sim$	$l\sim m=n$
Varies as,	$\propto$	$n\propto o$.
When quantities are to be taken together.	—— Vinculum,	$p\times(\overline{r+s})\times t=u$.
	( ) Parenthesis.	
	[ ] { } Brackets.	
	| Bar.	

CONCLUSION.

"Time works wonders." If so much is said of time, what should be said of the Equationor, which performs wonders in but a few seconds, reducing the work of hours to that of minutes. Writers on the Slide Rule, also adepts in its application, have published and spoken their views in favor of its general use. The author of this little book believes that instruction in its use should be made part of both common school and college education, to which end he has in preparation a form suited to reach the mind of a pupil who knows but multiplication and division. To both teachers and scholars study of the Slide Rule (simplified as proposed) would be a gain in relieving the labor of the former by quickening the perception of the latter.

In endorsement of such views I make the following quotations:

"Let Young America take hold of the Slide Rule and it will not be long before he will extend its usefulness."—F. T. Hodgson, Author of "The Mechanics' Slide Rule and How to Use it."

"Any person mastering its use will find endless opportunities for its employment." "In working with the Slide Rule every step in the process appears as consequent as the figures in a sum and as easily read by an intelligent eye." "The reason *why* and *how* numbers are multiplied, divided, squared and cubed by it are as clear as in arithmetical solution."—Chas. Hoare, C. E. Author of "The Slide Rule and How to Use it."

"It is well enough for every one to learn the rules of arithmetic, but as soon as they can possess themselves of instruments that are capable of taking the place of slower methods of calculating, they would do well to substitute them, using mechanical calculation instead of memorised rules."—Coleman Sellers, C. E., "American Machinist," July 9, 1891.